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JOURNAL
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ELISHA MITCHELL SCIENTIFIC SOCIETY

VOLUME XXIX OCTOBER, 1913 No. 2

GEOLOGICAL HISTORY OF WESTERN NORTH CAROLINA

BY JOSEPH HYDE PRATT

The State of North Carolina is divided into three physiographic divisions, which have been designated as the Coastal Plain, the Piedmont Plateau, and Mountain region. That part of the state lying to the west of the Blue Ridge is in the Mountain Region. This includes the Blue Ridge and the Great Smokies and the country between, which is cut across by numerous cross ranges separated by narrow valleys and deep gorges. The average elevation of this region is about 2,700 feet above the sea level, but the summits of a great many ridges and peaks are over 5,000 feet, while a considerable number of peaks have a height of over 6,000, the highest of which is Mount Mitchell with an elevation of 6,711 feet. Over the larger part of this region are to be found the older crystalline rocks, gneisses, granites, schists and diorites that are pre-Cambrian age which are greatly folded and turned on their edges. On the western and eastern borders of this mountain region, approximately along the line of the Blue Ridge and Great Smokies, there are two narrow belts of younger sedimentary rocks, consisting of limestones, shales, and conglomerates, and their metamorphosed equivalents, marbles, quartzites, and slates of Cambrian age.

The sedimentary rocks have been formed from sand, gravel, and mud which have been deposited as the result of alteration and erosion of the older rocks.

By the present position of the rocks we are able to obtain records regarding the order in which the rocks of western North

Carolina were formed, and thus obtain a geological history of the mountain section. All the rocks of western North Carolina are amongst the oldest geologic formations, although there is considerable variation in the time at which the various rocks encountered were formed. The oldest rock formation is known as the Carolina gneiss, which consists of large areas of mica and granite schists; and mica, granite, and cyanite gneisses. The exact origin of this rock has not been definitely determined; it may have resulted from the metamorphism of a granite rock. Mount Mitchell and the other mountain peaks of the Black Mountains are of Carolina gneiss, as are also Grey Beard, The Craggies, Sunset Mountain, Pisgah, Great Hogback (Toxaway), and Standing Indian (Clay County).

The next oldest rock formation of western North Carolina is known as the Roan gneiss, which is not as extensive as the Carolina gneiss, but forms much smaller areas and, as a rule, forms long narrow bands cutting the Carolina gneiss. They are also much less altered and are undoubtedly younger. Roan, High Knob, Big Yellow Mountain, Cocks Knob, the eastern slope of Craggy Dome and Bull Head Mountain, Nofat Mountain, and part of Cæsar's Head, are all of Roan gneiss. These mountains are, therefore, younger formations than those mountains composed of Carolina gneiss.

Another granite formation has been intruded into the Carolina and Roan gneisses, forming rather small areas in the northwestern portions of the mountains. These granites, known as the Cranberry and Beech granites, are observed in the vicinity of Blowing Rock, Beech Mountain, Rich Mountain, and part of Pumpkin Patch Mountain. A similar granite, known as the Henderson granite and of approximately the same age, is found over a considerable area of southeastern portion of Transylvania and Henderson counties and southwestern portions of Buncombe County.

All these rocks referred to above are of deep-seated origin and the lapse of time between the formation of the different ones was undoubtedly very great. They formed mountain ranges that were much higher than now observed, but these have

been subject to erosion which has brought them to their present outline.

The next formation was the lava rocks, which were poured forth upon the surface of the Archean rocks. These lava flows are of considerably later period than the granites and gneisses and are older than the overlying Cambrian sedimentary rocks, and they may belong to the Algonkian age. Some of these rocks were undoubtedly of volcanic nature, the intrusions coming to the surface as flows of lava and spreading out over the Carolina and Roan gneisses and the Cranberry and Beech granites. There was a very long interval between the formation of the last of the Archean rocks before the volcanic activity; and during this period these old Plutonic rocks were subject to very excessive erosion. This volcanic activity probably extended into the Cambrian time, and many of the lava flows were probably at the surface when the Cambrian strata were laid down. The indication of this is the finding of sheets of basalt conglomerate interstratified with the lower strata of the Cambrian. Rocks of this period include meta-diabase, found just north of Linville and to the east in Grandmother Gap and crossing the Yonahlossee road at several places; blue and green epidotic schists, which have been probably altered from basalt, such as are to be seen in the vicinity of Pineola and Montezuma, Avery County, and Hanging Rock, Caldwell County; a gray and black schist probably formed by the alteration of an andesitic rock, which is to be observed on Flat Top Mountain and Pine Ridge, Watauga County; and metarhyolite, such as is found on the slopes of Dugger Mountain, Sampson Mountain, and in Cook's Gap, Watauga County.

These Archean rocks, with the volcanic formations, were then subjected to a long period of erosion, and the sea at the same time encroached upon large areas of the dry land. The sediments deposited formed the rocks which are known as the Cambrian. Portions of the Archean rocks were submerged and at times uplifted, and there was not a continuous series of these sedimentary deposits.

These sedimentary rocks, formed from the erosion of the Archean and Algonkian rocks and from siliceous and calcareous

material deposited from animal life found in the sea, consist of conglomerates, sandstones, shale, limestone, and their metamorphic equivalents, quartzite, slate, and marble. These are observed very extensively over considerable areas of western North Carolina, but principally, as stated above, near the western and eastern sections of the mountain region. Grandfather Mountain is composed of one of these conglomerates of Cambrian age, as is also Grandmother Mountain, a large part of the area around Linville, and just to the east of Pineola. A narrow strip of these rocks is to be found extending across the extreme western part of Buncombe County, across Henderson and Transylvania counties. Brevard is situated in an area of these rocks, as is also Boylston, Mills River, and Fletcher, Henderson County. Practically all of Cherokee and Graham counties is composed of Cambrian rocks and the western parts of Clay, Macon, and Haywood counties. Swain County is composed largely of these Cambrian rocks, with the exception of an area of Archean rock that is exposed around Bryson and for some distance to the northeast. West of Asheville these Cambrian rocks are observed in the vicinity of Stackhouse, Hot Springs, and Paint Rock. They include all the limestones, such as are being mined at Fletchers, Mills River, and other places in Henderson and Transylvania counties; the limestones of Madison County; and the marbles of Cherokee, Graham, and Swain counties.

From the above it will be seen that the larger part of the area of western North Carolina is composed of the Archean rocks, representing the oldest rock formations.

Associated with the rocks described above are various minerals of economic importance, the history of which may be of interest in connection with the geological history of western North Carolina. The precious metals occur very sparingly in nearly all the counties of this section of the state, and in only a very few places has any attempt been made to systematically produce them, and this has been largely by placer mining. Both the rocks of the Archean and Cambrian age apparently contain minute quantities of gold, but in none of these have deposits been found of sufficient richness to be profitably mined. In the early history of western North Carolina it was customary

for many of the inhabitants to pan the various streams for gold and to pay their taxes in native gold. Just how much gold has been taken from western North Carolina in this way is not known; but it evidently runs up into several hundred thousands of dollars.

Iron was discovered in western North Carolina almost as soon as the country began to be settled, and the manufacture of iron dates back before the Revolutionary War. These early iron works consisted of the primitive Catalan forge blown by the water trompe. Such forges were in operation in Ashe, Mitchell, and Cherokee counties, and as late as 1893 one of these, the Pasley forge on Helton Creek in Ashe County, was in operation. These early forges supplied iron for all local uses and the forges in Cherokee County shipped a good deal into Tennessee. The most celebrated iron mine of western North Carolina is the Cranberry, and this iron was worked in Catalan forges as early as 1820. The following facts regarding the Cranberry iron may be of interest:

*"Cranberry Bloomery Forge, on Cranberry Creek; built in 1820; rebuilt in 1856; two fires and one hammer; made 17 tons of bars in 1857.

"Toe River Bloomery Forge, situated 5 miles south of Cranberry forge; built in 1843; two fires and one hammer; made about 4 tons of bars in 1856.

"Johnson's Bloomery Forge, 6 miles east of south from Cranberry; built in 1841; had two fires and one hammer; made 1½ tons of bars in 1856."

This ore made an excellent quality of iron and soon became known and attracted a great deal of attention throughout the United States. Since 1882 the mine has been worked almost continuously. Similar grades of iron ore are found in Ashe County, and the following is a summary of the history of the Catalan forges that were operated on these Ashe County magnetic ores:

"The Pasley forge was built by John Ballou at the mouth of Helton Creek in 1859; in 1871 it was rebuilt by the present owner, W. J. Pasley, and is now sadly in need of repairs.

"Helton Bloomery Forge, on Helton Creek, 12 miles N. N. W. of Jef-

*From "The Iron Manufacturer's Guide," 1859, by J. P. Leslie.

ferson; built in 1829; two fires and one hammer; made in 1856 about 15 tons of bars. Washed away in 1858. Another forge was built 1¼ miles lower down on the creek in 1802, but did not stand long.

"Harbard's Bloomery Forge was situated near the mouth of Helton Creek; built in 1807 and washed away in 1817.

"Ballou's Bloomery Forge was situated 12 miles N. E. of Jefferson, at the falls of North Fork of New River; built in 1817; washed away in 1832 by an ice freshet.

"North Fork Bloomery Forge was situated on North Fork of New River, 8 miles N. W. of Jefferson; built in 1825; abandoned in 1829; washed away in 1840.

"Laurel Bloomery Forge, on Laurel Creek, 15 miles west of Jefferson; built in 1847; abandoned in 1853.

"New River Forge, on South Fork of New River, ½ mile above its junction with North Fork; built in 1871; washed away in 1878."

The brown hematite ores of Cherokee County which occur in the Cambrian rocks were worked in forges as early as 1840, supplying the surrounding country with bar iron. We have record of the following forges:

"Lovingood Bloomery Forge, situated on Hanging Dog creek, 2 miles above Fain forge; built from 1845 to 1853; two fires and one hammer; made in 1856 about 13 tons of bars.

"Lower Hanging Dog Bloomery Forge, on Hanging Dog Creek, 5 miles northwest from Murphy; built in 1840; two fires and one hammer; made in 1856 about 4 tons of bars.

"Killian Bloomery Forge, situated ½ mile below the Lower Hanging Dog forge; built in 1843; abandoned in 1849.

"Fain Bloomery Forge, on Owl Creek, 2 miles below the Lovingood forge; built in 1854, two fires and one hammer; made in 1856 about 24 tons of bars.

"Persimmon Creek Bloomery Forge, situated on Persimmon Creek, 12 miles southwest from Murphy; built in 1848; two fires and one hammer; made in 1855 about 45 tons of bars.

"Shoal Creek Bloomery Forge, situated on Shoal Creek, 5 miles west of the Persimmon Creek forge; built about 1854; one fire and one hammer; made in 1854 about ½ ton of bars."

With the exception of the blast furnace at Cranberry which uses the magnetic iron ore from the Cranberry mine, no other furnace has been erected in western North Carolina for the treatment of iron ores; and when the Pasley forge on Helton Creek went out of commission, there was no other point in west-

ern North Carolina, except the Cranberry, where iron was being made. A small amount of ore has been shipped from time to time from various localities.

Copper mining at one time was a prominent industry of western North Carolina; and while I have no definite data as to when copper mines were first operated in western North Carolina, we do know that copper properties were worked before the Civil War, principally in Ashe and Alleghany counties. The most noted mine was the Ore Knob, which is in the southeast corner of Ashe County near the top of the Blue Ridge and about two miles from New River. This mine was first opened sometime before the War, but it was not until some years after the war that it was developed to any great extent. The ore deposit was worked to a depth of 400 feet by means of numerous shafts and drifts. The mine was equipped with a smelter for producing a high grade of copper. The amount of copper produced and shipped from January, 1879, to April, 1880, which was the time the mine was fully operated, was something over 1,640 tons. The cost to produce and market this copper was $.1039 a pound. The mine has not been worked since about 1882. Other copper properties that were worked were the Copper Knob or Gap Creek mine in the southeast part of Ashe County; the Peach Bottom mine on Elk Creek, Alleghany County; the Cullowhee mine on Cullowhee Mountain, and Savannah mine on Savannah Creek, Jackson County.

Another mineral for which western North Carolina is noted is corundum. In 1870, Mr. Hiram Crisp found the first corundum that attracted attention to the present mining region of North Carolina, at what is now the Corundum Hill mine. A specimen was sent to Prof. Kerr, then State Geologist, for identification, and considerable interest was aroused when it was discovered that it was corundum. In the same year, Mr. J. H. Adams found corundum in a similar occurrence at Pelham, Massachusetts.

In 1870-71, much activity was displayed in the search for corundum in the peridotite regions of the southwestern counties of North Carolina, and new localities were soon brought to

light in Macon, Jackson, Buncombe, and Yancey counties. In 1871, Dr. Genth discovered the emery of Guilford County. About this time, Mr. Crisp and Dr. C. D. Smith began active work on the Corundum Hill property, and obtained about a thousand pounds of corundum, part of which was sold to collectors for cabinet specimens. Some of the masses that were found weighed as much as 40 pounds.

Systematic mining for corundum did not begin until the fall of 1871, when the Corundum Hill property was purchased by Col. Chas. W. Jenks, of St. Louis, Missouri, and Mr. E. B. Ward, of Detroit, Michigan, and work was soon begun under the superintendence of Col. Jenks. This was the first systematic mining of common corundum, as distinguished from emery and the gem varieties, ever undertaken, while the first mining of the emery variety of corundum in America was at Chester, Massachusetts. The Corundum Hill mine produced corundum almost continuously from 1872 to 1901. Other mines that have produced corundum are the Buck Creek mine in Clay County; the Ellijay mine in Macon County; the Carter mine in Madison County; and the Higden mine and Behr mine in Clay County.

Mica mining in North Carolina began about 1870, and for the first 5 years practically all the mica mined was handled by Heap and Clapp, and was obtained from the mines of Mitchell and Yancey counties. Mica has continued to be mined almost constantly since that time not only in Yancey and Mitchell counties, but in Ashe, Buncombe, Haywood, Jackson, and Macon counties. There are a great many old workings on these mica deposits and before they had been investigated and the mica discovered they were supposed to be old workings of the Spaniards who were hunting for silver. It is now supposed that these old workings were made by the Indians for these sheets of mica; and it is known that mica has been found in Indian mounds and was used by the Indians who inhabited what is now Ohio in the manufacture of their beads. North Carolina mica is still known as standard mica, as it was reckoned from the beginning.

Several other minerals should be mentioned in connection with the descriptions given above as they were first identified in North

Carolina. The mineral that stands out most strikingly is the rhodolite, a gem mineral which was discovered in Macon County about 1894 and was given its name from the resemblance of its color to that of certain rhododendron.

Mitchellite, a variety of chromite, was discovered near Webster, Jackson County, 1895, and was named in honor of the late Prof. Elisha Mitchell of North Carolina.

Wellsite, one of the minerals of the zeolite group, was discovered in 1892 at the Buck Creek mine, Clay County, and was named in honor of Prof. H. L. Wells, of Yale University.

The following, belonging to the vermiculite group of minerals, have been found associated with corundum, and were described by Doctor Genth; they were all discovered about the same time in 1872 or '73: culsageeite, a variety of jefferisite, found at the Corundum Hill mine and named for a postoffice near that place; kerrite, found at Corundum Hill mine, and named in honor of Mr. W. C. Kerr, former State Geologist of North Carolina; maconite, found at the Corundum Hill mine and named after Macon County; lucasite, found at the Corundum Hill mine and named after Dr. H. S. Lucas, who owned the Corundum Hill mine; and willcoxite, found at the Buck Creek (Cullakenee) mine, Clay County, and named after Joseph Wilcox of Philadelphia. Auerlite, found at the Freeman mine, Green River, Henderson County, about 1888, it is a thorium mineral, and was named for Dr. Carl Auer von Welsbach; hatchettolite, a tantlum-uranium mineral, was found at the Wiseman Mica mine, Mitchell County, about 1877, and was named after the English chemist, Charles Hatchett; phosphuranylite, a uranium mineral, found at the Flat Rock mine, Mitchell County, about 1879, and named from the chemical composition of the mineral; and rogersite, a niobium mineral, found at the Wiseman Mica mine, Mitchell County, about 1877, named after Prof. W. B. Rogers.

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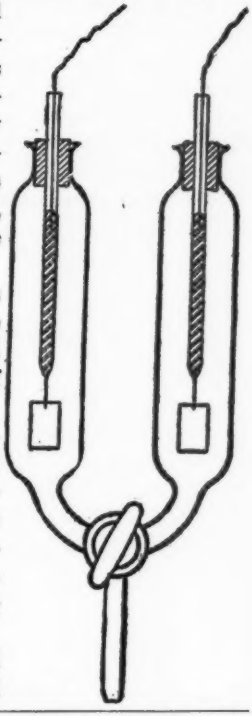
8 and 9 on the Mining Industry in North Carolina, 1901, 1904, 1905. U. S. G. S. Geologic Folios, Cranberry, 1903; Asheville, 1904; Mount Mitchell, 1905; Pisgah, 1907; Roan Mountain, 1907; Nantahala, 1907.

CHAPEL HILL, N. C.

ELECTROMOTIVE FORCE OF SILVER NITRATE CONCENTRATION CELLS*

BY JAMES M. BELL AND ALEXANDER L. FEILD

The electromotive forces of concentration cells — two aqueous solutions of silver nitrate between silver electrodes, $Ag/AgNO_3/AgNO_3/Ag$—have been measured by Miesler,[1] by Nernst,[2] by Negbaur,[3] by Cumming and Abegg,[4] and by Cybulski and Dunin-Borkowski.[5] Non-aqueous solutions have been employed in similar measurements by Bodländer and Eberlein,[6] by Neustadt and Abegg,[7] and by Roshdestwensky and Lewis,[8] the non-aqueous solvents being ethylamine, methylamine, methyl alcohol, ethyl alcohol, acetone and pyridine.



The present paper contains results of measurements of the electromotive force in aqueous solutions and in ethyl alcohol solutions over a wider range of concentrations than heretofore used.

The water used in making up the solutions was distilled several times and had a low conductivity. The ethyl alcohol stood several days over quicklime and was then distilled from barium oxide. Baker's analyzed silver nitrate was used, the impurities present being negligible in amount.

The cell is shown in the figure, and consists of a U-tube with outlet tube and

* Reprinted from the Journal of the American Chemical Society, Vol. XXXV. No. 6. June, 1913.

[1] *Monatshefte*, 8, 193, 365 (1887); *J. Chem. Soc.*, 52, 1073 (1887); 54, 13 (1888).
[2] *Z. physik. Chem.*, 4, 155 (1889).
[3] *Wied. Ann.*, 44, 737 (1891).
[4] *Z. Elektrochem.*, 13, 18 (1907).
[5] *Anz. Akad. Wiss. Kraukau*, 1909, 660. *Chem. Zentr.*, 1909, II, 1295.
[6] *Ber.*, 36, 3945 (1903).
[7] *Z. physik. Chem.*, 69, 486 (1909).
[8] *J. Chem. Soc.*, 99, 2138 (1911).

three way stock-cock. While the cell was in the thermostat, the outlet tube was capped. The three-way stopcock permitted the removal of either solution, and permitted the separation of the solutions in the limbs of the tube until the measurement was about to be made. The electrodes were of platinum foil about 1 cm. square, welded to platinum wire which was fused through a glass tube containing mercury. Frequently during the course of the experiments, the platinum foil and wire were plated with silver from silver nitrate solutions acidified with nitric acid. When the two solutions were at the same level in the two limbs of the U-tube, connection between them was made by opening the stop-cock, and the E. M. F. was determined by the ordinary potentiometer method. The galvanometer was sensitive to 0.00005 volt even with a large resistance in the circuit. An electrically heated and electrically controlled thermostat was run at 25° constant to 0.01°. The measurements were irregular until the metal coating of the thermostat tank was grounded.

Measurements of the electromotive force of such combinations were constant within 0.0001 volt for at least 20 minutes after putting the solutions in contact. The table below gives the mean of two values obtained when different solutions and freshly plated electrodes were used. These duplicate measurements differed at most by 0.0003 volt and in the majority of cases by not more than 0.0001 volt.

TABLE I

	Mols/liter c_1	Mols/liter c_2	E.M.F. obs. Millivolts.	$K=\frac{E}{\log_{10} c_1/c_2}$
(1)	1.0	0.1	47.2	0.0560
(2)	1.0	0.01	103.6	0.0584
(3)	0.3	0.03	53.6	0.0606
(4)	0.3	0.003	113.8	0.0616
(5)	0.1	0.01	56.6[1]	0.0608
(6)	0.03	0.003	60.1	0.0623
(7)	0.01	0.001	60.2[2]	0.0623

These readings show satisfactory agreement among themselves, for the sum of (1) and (5) should equal (2), and the sum of (3) and (6) should equal (4). The differences are 0.0002 and 0.0001 volt respectively.

[1] Cumming finds 59.0 millivolts.
[2] Cumming finds 61.8 millivolts.

The Nernst formula for cells of this type is

$$E = \frac{2v}{u+v} \frac{RT}{nF} \log_e \frac{c_1}{c_2}$$

where c_1 and c_2 refer to the concentration of silver ions and not to the concentration of silver nitrate. It is necessary to know the values of u and v, the migration ratios of Ag^+ and NO_3^-. With solutions for which u and v are constant, values proportional to the ionic concentrations are given by the conductivities of the solutions, and these are inversely proportional to the resistance of the solutions. Cumming and Abegg conclude "that

TABLE II

Concentration.	Resistance.
1.0	3.486
0.3	9.646
0.1	24.25
0.03	73.80
0.01	206.49
0.003	679.32
0.001	1907.0

conductivity seems to be an exact measure of ion concentration." The preceding table contains the results of measurements of the resistances of the above solutions.

Measurements of the migration ratios at each concentration were not made. The table given by Lehfeldt[1] indicates that the migration ratio for silver nitrate is fairly constant up to a concentration of 0.2 mols per liter. Assuming this value to be constant the above becomes

$$\frac{E}{\log_{10} c_1/c_2} = \frac{2v}{u+v} \cdot \frac{RT}{nF} \cdot \log_e 10 = K.$$

The values of $K = \frac{E}{\log_{10} c_1/c_2}$ are given in the last column of Table I and with the exception of cells 1 and 2, where normal solutions were used, they are fairly constant. This confirms the results of previous investigations, which show that the

Nernst formula holds for dilute solutions of silver nitrate. From the value of K found above the values of u and v may be calculated by substitution of the proper values of the other quantities in the equation

$$K = \frac{RT}{nF} \frac{2v}{u+v} \log_e 10$$

Taking K=0.0623 the value of v is 0.523 while the observed value, given by Lehfeldt[1] is 0.528.

The table compiled by Lehfeldt indicates that the value of v is less for concentrated solutions and this would make the value of K smaller in proportion. The present results are in harmony with this fact, although it is impossible as yet to calculate the electromotive force between two solutions of silver nitrate of such concentrations that the migration ratio of the two are different.

The following table gives the results of measurements of the electromotive forces of three combinations where ethyl alcohol was used as solvent.

TABLE III

	Mols/liter c_1	Mols/liter c_2	E.M.F. obs. Millivolts.	$K=\frac{E}{\log_{10} c_1/c_2}$
(1)	0.1	0.01	47.0	0.068
(2)	0.1	0.001	106.6	0.071
(3)	0.01	0.001	59.7	0.074

The experimental values are consistent among themselves as the sum of (1) and (3) is 106.7 against 106.6 for (2).

The relative ionic concentration of silver ions was determined by conductivity measurements the results being given in the next table.

TABLE IV

Concentration.	Resistance.
0.1	208.5
0.01	1024.0
0.001	6420.0

Again assuming that at all the concentrations employed the values of the migration ratios remain constant, the value of K

[1] *Electrochemistry*, p. 256 (1904).

was determined by the same formula as for aqueous solutions. As these values vary somewhat (see Table III), it seems probable that the migration ratios of Ag^+ and NO_3^- are not constant even for concentrations below 0.1*N*. Taking K=0.074, the value of v is 0.62.

SUMMARY

The electromotive forces of concentration cells containing solutions of silver nitrate in water at 25° are in accord with the Nernst formula for dilute solutions. Where higher concentrations were employed the calculated value of the electromotive force is greater than the observed because the migration ratio v is smaller at the higher concentrations. This affects two factors in the Nernst equation, *viz.*, $2v/u+v$ and $\log c_1/c_2$. The latter factor is affected because the ratio of the ion concentrations c_1/c_2 is determined from conductivity measurements and this method of determination is valid only when the migration velocity remains constant. The value of migration ratio for dilute solutions calculated from the above results agrees closely with the values found by direct experiment.

For ethyl alcohol solutions the migration ratio apparently varies even at concentrations below 0.1 *N*. The value of v calculated from the most dilute solution was 0.62.

CHAPEL HILL, N. C.

ANNUAL ADDRESS OF THE PRESIDENT OF THE NATIONAL ASSOCIATION OF SHELLFISH COMMISSIONERS, NORFOLK, VA., APRIL 23, 1913

BY JOSEPH HYDE PRATT

It is with a great deal of pleasure that I, as President of the National Association of Shellfish Commissioners, respond for the members of the Association and delegates to this convention to this most cordial welcome that has been extended to us. I can assure the good people of the city of Norfolk and of the State of Virginia that it is very gratifying to us to be able to hold this fifth annual convention of our Association in the old historic State of Virginia, which has always stood in the foreground of progress, and has played such a vital and important part along all lines in the development of our great nation. The warm, sincere, and open-hearted hospitality for which Virginia has always been noted, is now being extended to us. There are but very few instances in the history of this great State where this warm and open-hearted hospitality has not been shown to those who desired to come within her borders, such as: the refusal of the State to accept certain governors that England wished to force upon her; the warm but inhospitable reception that was extended so effectively to Cornwallis and his followers during the Revolutionary War; and the polite and energetic request that was given to certain visitors who insisted on coming into the State during the sixties that their room was preferable to their company. I believe, outside of such instances as I have mentioned, that Virginia has at all times extended the right hand of fellowship and free hospitality to all who wish to come and visit or dwell within her borders. Even those whom she turned away on account of certain differences have, when the differences became adjusted, been and are now being received with the same sincere cordiality as if these differences had never existed.

We cannot, as we meet together in this State, prevent ourselves from reminiscing regarding the early history of Virginia; from

the spring of 1607, when the first permanent English colony was established at Jamestown, Va.; and, as we do this, we realize that to the men who assisted in the building up of this colony and to all Virginians who have followed, even to perhaps the greatest of all, who now occupies the highest office in the gift of the people,—President Woodrow Wilson,—that to these men the nation is indebted for much of its success and its rise to the greatest nation in the world.

It can be truthfully said that not only in the United States but also in our own States individualism and sectionalism, as opposed to a national or state community spirit, has reached in the past few years a point that is of positive detriment to the best growth and development of our country. We believe, however, that we now have at the head of our national government a broad-minded, conscientious man whose attention is directed to measures of nation-wide importance, which he will endeavor to see are considered in a manner that will be for the best interest of the country at large, and not for the benefit of any particular local section or community or interest at the expense of the country as a whole. I believe that the influence of this man is going to be wide-spread throughout the nation, so that various measures that are coming up in the states will be considered from the standpoint of the State, and not from the standpoint of the county or township. It is undoubtedly true that questions that come up relating to the conservation and perpetuation of our natural resources of whatever character they may be, must be considered from at least a state, and in some cases a national standpoint, if the best results or even any good results are to be obtained; and this is very true in connection with the shellfish industries.

Virginia is one of the few South Atlantic States that has taken a decided practical step looking toward the conservation and perpetuation of her shellfish industry, and through the conscientious work of her able commissioner, Hon. W. McDonald Lee, she has reached the place where she can point with pride to what the State is accomplishing in the oyster industry. Her Lynnhaven and James River oysters are famous not only in the

State but throughout the country, and she has made them abundant so that she can supply the greatest demand that may arise for them. I have used the words "made them abundant" advisedly, inasmuch as the results accomplished have been due to the actual work of man in the cultivation and planting of the oyster as well as assisting by adequate statutes the growth and reproduction of the oyster on the natural rock. The oyster industry is on a paying basis, and each year is enabled to pay into the General Treasury of the State a very satisfactory fund, after all expenses have been met. This could only have been accomplished as a state-wide measure.

Man himself is one of the most important factors in decreasing the supply of oysters and other shellfish in the waters of the several states, due largely to his selfish interest and to his idea that anything that comes out of the sea is his by a God-given right, and that the State has no authority over it whatever. Many of the natural oyster rocks or reefs may have been partially or wholly destroyed by becoming muddied or sanded, due to very severe storms, thus smothering the oysters; or the beds may have been destroyed by some parasite; or, because of the certain changes of the coast line, waters may have become too fresh; and thus the natural rocks have been destroyed. Notwithstanding the fact that these causes may account for the destruction of many natural rocks, it is undoubtedly true that the most important influence is the one that has to do with the actual taking of the oysters themselves. This is especially true of the lobster, which in many sections has been almost entirely exterminated by overfishing. The oyster and the clam have practically no chance whatever to protect themselves or to escape their worst enemy, man; but, though an enemy, it is also through the efforts of man that the destruction wrought in many places must be and has been remedied. If it had not been for the conservationist or perhaps I might say in connection with the oyster industry, the man who appreciated the oyster as a delicious food, realizing that unless some steps were taken by the State or National governments to protect it and prevent over-oystering of the natural rocks, the oyster would be exterminated; we would be today in many, if not all of the

states, without this form of food. There were such men who came to the assistance not only of the oyster but of other shellfish. In many instances, however, it would have been too late with the oyster if it had not been previously demonstrated that its cultivation was a commercial proposition, and this had been taken up very extensively in those states where the natural rock had been very nearly depleted. Besides producing oysters on the made rock, another result of the cultivation of the oyster has been that the natural rocks have in several states begun to increase and become again very productive, which is undoubtedly due to the great quantity of spat that was produced by the cultivated beds, and which settled on the natural rocks.

Such recommendations as are made for the perpetuation and cultivation of the oyster and the protection and perpetuation of other shellfish can only be carried out by a state's taking the problem and considering it as a state proposition. Where this has been done the results have been most beneficial and gratifying, and the oyster industry of these states has been revived and become a very profitable one. There are, however, still many states where the problem has not yet been successfully solved; and it is found, upon investigation, that the reason for this is that state legislators have not and are not now considering the question as a state problem, but are permitting the local communities to have enacted laws relative to the oyster industry, and are not taking any steps from the standpoint of the state for the protection of these shellfish. The result is, that in several of the states, as: North Carolina and Georgia, oystering has reached a very low ebb, so low in fact that it is scarcely to be reckoned with in considering the oyster industry of this country.

The work of this Association is to consider and assist in the solving of all problems that may come up in regard to the perpetuation of the various shellfish; and it has tried and is still trying to bring every state that has shell fisheries to a realization of the absolute necessity of the state taking up the problem and passing adequate legislation covering the whole industry in the state. The Association has had the hearty co-operation of the United States Bureau of Fisheries in this work, and we believe that the considerable progress that has been made in the

shellfish industry can be directly traced to the work of this Association.

With the passage of adequate laws regulating the fishing of the oyster, and its cultivation, problems immediately come up that must be considered and solved, such as:

What are natural rocks?

What areas shall be open for cultivation of the oyster?

Shall such areas be leased or sold?

How much area shall each individual be permitted to take up?

How shall the oyster bottoms be taxed?

What regulation shall be made in regard to the production and shipment of seed oysters?

What measures shall the State take to protect the beds that are being cultivated; for the protection of the natural rock?

Pollution of oyster rocks and its prevention.

Effect of dumping all waste material into our harbors and bays which may result in the pollution of oyster rocks and clam beds, or may cover the oyster rock and thus smother the oysters.

Shall the areas of the natural rock be mapped or the areas that are leased or sold for cultivation?

Uniform seasons for catching oysters in adjoining states.

The solution of these problems is now being taken up by the various states and also the Federal Government; and they are slowly but surely being solved, and we believe in the interest of the shellfish industries.

As can readily be seen from these problems, it will be absolutely impossible to solve them unless it is done by the states as state propositions. The problems vary in the different states and in some that relating to the oyster has been almost entirely solved, but there still remains a great deal to be done in connection with the perpetuation of other forms of shellfish. The necessary measures that are required to better the various shellfish industries will be accomplished just so fast as we are able to educate those who make a livelihood out of these industries, as to the need of conservation; bring the rest of the people of that particular state to a realization that they too have a decided personal interest in the conservation of these industries; and

cause each of these classes of people to realize that the shellfish do not belong to the individual but to the state, and, therefore, the state has a right to insist upon their protection and perpetuation.

The National Association of Shellfish Commissioners is trying to bring together the best information obtainable regarding the problems suggested above; and they are holding conventions to discuss these problems and work out, if possible, a plan which will eventually solve them. The information at our conventions has been of very great assistance to the commissioners of the various state, and is being utilized by them for the good of the industry.

Some states are better equipped than others for carrying on experimental work in connection with certain problems, and, although the results of their experiments are of peculiar value to that state, yet they are of great value to all who are interested in the same or similar problems to those that have been investigated. Our Association should be and is a clearing house through which each State Commission can obtain the benefit of the results obtained by the others.

The discussions that have taken place at our previous conventions on such subjects as:

The leasing vs. the sale of sea bottoms for oyster and clam cultivation;

The method and rate of taxation of oyster and clam bottoms;

The pollution of oyster bottoms;

have all been of very great interest, and the fervor and earnestness with which the delegates to the convntion entered into the discussion resulted in the co-ordination of our ideas and theories, and emphasized the value of co-operation.

We sometimes become impatient at the length of time required to have our ideas, suggestions and recommendations put into practice by our state legislators, and we wonder why they can be so ignorant on such an important subject, as the "Shellfish Industry." Yet we cannot expect them to be very familiar with a subject that has taken us years to understand and realize its great value. What we do, however, have a right to become impatient over is the often apparent unwillingness of our legis-

lators to accept the recommendations of the Shellfish Commissions regarding the industry or that their ideas are of any particular value; and instead pass legislation regarding the industry that is almost diametrically opposite to our suggestions. This is frequently done for political reasons, and the interests of the state have been sacrificed for self advancement. I believe, however, the tide is turning and that we are entering upon an era when man's love of country and his true patriotism will outweigh the thought of self; and in deciding questions of state his query will be: What effect will this measure have upon the country and upon my state, and not what will be the political effect upon me. When we have broadened and developed to such an extent that we consider in these great questions first, our country's interest, then our state, then our county, and last our own individual community, then and then only, will we be able to obtain the best solutions to these problems.

Our co-operation should not only be between the states but between the states and the U. S. Bureau of Fisheries. There should be a more adequate appropriation made by Congress to the Bureau of Fisheries for investigations relating to the shellfish industry. There is a wide field for work which should be done largely by the Federal Government, and in co-operation with the several states. The importance and value of the industry warrant our making a vigorous demand upon Congress for such an appropriation.

The oyster, clam, scallop, the lobster, the crab and the terrapin must all receive the attention of the Shellfish Commissions.

The sessions of our convention are open to the public and we will gladly welcome any who are interested enough in the subject to attend; and we may in this way impress upon laymen the value and importance of the industry we represent.

In closing, I wish to express to you Virginians our extreme regret that illness has kept Governor Mann from meeting with us. We miss his word of cheer and guidance, and voice with you the prayer that his illness may not be for long, and that he will soon be restored to his State in full vigor and health.

CHAPEL HILL, N. C.

LIME ON SOILS

BY JOHN E. SMITH

The various operations of tillage are performed for the purpose of enabling the plant to obtain the food necessary in the process of growth. Certain substances are sometimes added to the soil to increase its productivity; these are known as soil amendments and lime is one of the most useful of them.

CORRECTS THE ACIDITY

An acid condition results from the decay of organic matter, is brought to the top soil from the subsoil by capillary water, is produced by nitrifying bacteria, and is formed in other ways. All forms of lime (except gypsum) readily counteract or neutralize this condition, one ton per acre in most cases being sufficient to keep the soil neutral for two or three years.

AIDS NITRIFICATION

The acidity of soils is somewhat injurious to the growth of many plants and in many instances is fatal to the legumes (clover, vetch, alfalfa, etc.), whose power to assimilate and store nitrogen is dependent on the activity of bacteria that thrive in a neutral or slightly alkaline soil but cannot live in the presence of much of the acidity which in part is the product of their own work. A supply of lime in the soil neutralizes the acid as rapidly as it is formed and thus prevents its accumulation and maintains a condition favorable to the rapid growth of nitrifying bacteria. Lime is therefore essential to the successful growth of leguminous plants sooner or later.

IMPROVES THE STRUCTURE

By structure of the soil is meant the arrangement or grouping of the soil particles. This is very intimately related to pore space, water holding capacity, and to the movements of soil moisture.

The addition of lime to clay soils is a strong factor in preventing cloddiness and in producing that most desirable granular, crumb-like structure which constitutes "good tilth," so

necessary in retaining the moisture in the soil during dry weather. It also increases the permeability of the soil for air. Nearly all forms of lime readily improve the soil structure.

For sandy soils a small amount of lime carbonate will serve to make the structure slightly more compact by cementing some of the particles together, thereby improving the power of the soil to hold capillary water and preventing its drying so readily.

FORMS OF LIME

In nature the chief source of "lime" is the common mineral calcite which occurs extensively as beds of fossils shells, often not distinguishable, and these beds according to their purity, the degree of consolidation, method of deposition, subsequent changes, and to the kind and nature of the contributing organisms, are classified as limestones, marls, chalk, marble, etc.

This material is applied to the soil in three forms; decayed limestone, marl, etc., these substances ($CaCO_3$) ground, and that which has been burned at a high temperature. In the process of burning, a gas (carbon dioxide, CO_2) is given off and calcium oxide (CaO), quicklime, remains. When quicklime is allowed to slack slowly in dry air, it again assumes the form of a carbonate and is called air-slaked lime. If water be added to the quicklime, the mixture forms calcium hydrate, $Ca(OH)_2$, and is known as water-slaked or hydrated (caustic) lime. If the slaking take place in damp air, the quicklime absorbs from the air some moisture and some carbon dioxide the result being a mixture of lime carbonate and hydrated lime.

Related Forms.—Dolomite is a calcium magnesium carbonate ($CaCO_3$, $MgCO_3$), sometimes incorrectly called magnesian limestone. It occurs extensively in the Appalachian Mountains and is found in Virginia, Tennessee, North Carolina, Georgia, and Alabama, where it is frequently called "marble."

Gypsum, the hydrated sulfate of calcium ($CaSO_4$, $2H_2O$), is ground and sold on the market as "Land Plaster."

TABLE OF EQUIVALENTS

Quicklime CaO		Hydrated lime $Ca(OH)_2$		Dolomite $CaCO_3$, $MgCO_3$		Pure, ground limestone $CaCO_3$		Marl 85% $CaCO_3$		Marl 75% $CaCO_3$		Marl 60% $CaCO_3$
56 lb.	=	74 lb.	=	92 lb.	=	100 lb.	=	118 lb.	=	133 lb.	=	167 lb.
.75 ton	=	1 ton	=	1.24 ton	=	1.35 ton	=	1.59 ton	=	1.8 ton	=	2.26 ton
1 ton	=	1.35 ton	=	1.64 ton	=	1.78 ton	=	2.11 ton	=	2.38 ton	=	3 ton
$1.78	=	$1.35	=	$1.09	=	$1.00	=	$ .85	=	$ .75	=	$ .60

100 lbs. of pure limestone will produce when burned, 56 lbs. of quicklime which, when air-slaked, becomes 100 lbs. of finely powdered lime carbonate. If the 56 lbs. of quicklime be water-slaked, it unites with 18 lbs. of water to form 74 lbs. of hydrated lime. 100 lbs. of ground limestone contains the same amount of lime as 167 lbs. of 60% marl; one ton of hydrated lime is equal to three-quarters of a ton of quicklime and to two and one-fourth tons of 60% marl. If a given amount of ground limestone (one ton for example) is worth $1.00, the same quantity of 75% marl is worth (by weight) $.75, and of hydrated lime, $1.35. This however does not indicate the relative values of their effects on the soil.

ADAPTATION OF FORMS

Gypsum.—This form of calcium does not neutralize the acidity of the soil but on the other hand tends to increase it and should not therefore be used except on neutral or alkaline soils and then only in small quantities. It frequently changes some of the potash of the soil to the soluble form and sometimes makes more phosphorus available for the use of the plant.

In its effects on soil structure it decreases the rate of movement of capillary water and consequently reduces evaporation from the surface (in sandy soils 27%, King, The Soil, p. 177).

Gypsum accelerates the process of nitrification more than any other known substance. Its relation to lime in this respect may be seen in the following figures: lime carbonate, 13.3; gypsum, 100 (Hilgard, Soils, p. 147). It should be used on soils for this purpose only.

Dolomite.—This rock when ground very fine and applied to the soil has much the same effect as the lime carbonate especially on the first two or three crops following its application.

Later by successive additions of it to a field, the magnesia might be increased to an injurious extent, but this could be avoided by the occasional use of lime carbonate. Companies quarrying this material might utilize some of their wasted stone dust by selling it for this purpose. The burned dolomite is strongly caustic and should not be put on the land.

Hydrated Lime.—This form greatly hastens vegetable decay and often causes waste leading toward exhaustion of the organic content of the soil. When it is applied therefore, more organic matter such as barnyard compost, legume crops, etc., must be added except on soils containing peat, etc.

It corrects the acidity of the soil more quickly than other forms of lime and may produce a better increase in the yield during the first two or three years. For this reason it is frequently used by tenants.

On heavy clay soils this form is the most effective in producing a good granular, crumb-like structure and thus aids in the retention of moisture near the surface.

Lime Carbonate.—Ground limestone readily corrects the acidity of the soil, assists greatly in producing a condition favorable to the growth of nitrifying bacteria, and directly or indirectly renders available other plant foods such as phosphoric acid and potash. It changes vegetable materials into neutral humus at once and concentrates their nitrogen.

A liberal supply of lime carbonate added to orchard lands will increase the sweetness of the fruit (grapes included) if the lime was previously deficient in amount.

Lime carbonate greatly increases the flocculation of soil particles into granules and thus improves the texture of the soil.

Lime carbonate is useful in nearly every way in which lime is valuable as a soil amendment.

SUMMARY AND CONCLUSIONS

Under average conditions plants use annually nearly half a ton of lime carbonate per acre.

The effectiveness of lime added to the soil depends very largely on its fineness of grain (texture) and on its being thoroly mixed with the soil.

The finest grained limes are the air-slaked and the hydrated forms.

Unground limes and marls should be extremely well decayed.

The degree of acidity present and the amount of plant food in the soil determine the amount of lime to be used.

One or two tons per acre applied every two or three years is much better than larger amounts added at longer intervals.

Lime should be shipped in its most condensed form (quicklime) and hydrated on the farm where it is used.

Ground lime should be applied in the summer or fall to be available for the next spring crop. Hydrated lime is put on (do not mix it with phosphates) about a month before seeding.

The limestones and most of the marls of the Atlantic and Gulf Coastal Plains are desirable for use as ground material.

In Europe and America nearly all of the experiments conducted to test the relative value of ground limestone and the hydrated lime as amendments to soils deficient in lime, have produced results favorable to the lime carbonate.

CHAPEL HILL, N. C.